7.—GRANITIC ROCKS FROM CANNING DAM

by

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INTRODUCTION.

The Darling Range in the vicinity of Perth is made up largely of a granitic complex of granite gneisses, migmatites (hybrid gneisses) and massive granites, all of which are traversed by aplites, pegmatites, and quartz veins, and by still later basic intrusives which vary in character from quartz dolerites to epidiorites. The granitic rocks in places show faint traces of gneissic structure but the nature of this granite complex is largely obscured by the weathering of rock outcrops and the accumulation of weathering products and is not fully realised until freshly broken exposures in quarries are available for examination.

Recent work on these granitic rocks as exposed at Armadale (Prider, 1941), and Cardup (Thomson, 1941) indicates that there were at least two distinct phases in the formation of this complex:—(i) a period of granitisation or migmatisation which yielded hybrid granite gneisses from a pre-existing basic igneous terrain and (ii) the intrusion of a later massive granite with its associated end phase intrusions of aplite, pegmatite and vein quartz. An account of the geology of an area in the vicinity of Gosnells recently published by Davis (1941) indicates that in that locality only the later massive granite is developed. An earlier paper by Clarke and Williams (1926) which describes the geology of areas near Darlington and Roleystone, gives information regarding the granitic rocks of these areas from which it appears (loc. cit. p. 167) that at Darlington only the younger massive granite is developed while at Roleystone the older granite gneisses containing "biotitic segregations" (which are undoubtedly the equivalent of the basic xenoliths in the Armadale hybrid gneisses) are predominant, although it was considered at that time that the rocks of Darlington and Roleystone were probably of a single petrological unit showing wide variations in character from place to place. Fletcher and Hobson (1932) have described granitic rocks from a northerly extension of this mass at Upper Swan but only recognise one type of granite in this locality. A preliminary re-examination of some of these rocks by the author has indicated, however, that further work in this locality may yield results of interest so far as the northerly extension of the granitic complex is concerned. Miles (1938, p. 28) has noted that granitic rocks south of Chittering, which are very similar to the granites of the Darlington area, are intrusive into the older metasedimentary Chittering Series (loc. cit. p. 27) and these probably represent the most northerly extension of the granitic complex in the Darling Range.

At Canning Dam (which is situated twenty miles south-east from Perth) the two main phases of the formation of the granitic complex are very distinctly seen in the quarry opened up in 1933 for concrete aggregates used in the construction of the dam. Previous geological work in this neighbourhood is confined to two geological reports, one by Campbell (1904) which contains a geological map of the Canning River valley and the other by Feldtmann (1916) dealing with the rocks in the vicinity of the dam site—Feldtmann notes the great variation in structure and mineralogy of the granites but does not give any detailed descriptions of the rocks, of which only natural exposures were available at that time.

THE GRANITIC COMPLEX IN THE CANNING DAM QUARRY.

The exposures in the Canning Dam quarry which is situated approximately 300 yards south-west from the dam are similar in many respects to those in the road board quarry at Armadale (Prider, 1941, p. 29) and the granitic complex in this locality is essentially the same as has already been described at Armadale. In view, however, of the excellence of the exposures and the contribution that the Canning Dam rocks makes to our knowledge of the younger granite it is felt that some description of these rocks is warranted. Attention will be given only to the granitic rocks and consideration of the character of the later basic rocks will be deferred for a later paper, when it is hoped to deal with the quartz dolerites and epidiorites of the Darling Range.

The most informative exposures are to be seen in the east and south walls of the quarry and in various large boulders broken out during quarrying. Some of these are illustrated in Plate 1, figs. 1-2, which require very little explanation. Fig. 1 in Plate 1 is a view of a part of the east wall showing a large xenolith of the earlier dark coloured hybrid gneiss enclosed by the younger massive granite which also carries smaller xenoliths of the older material. It will be seen that the boundary between xenolith and host is extremely well defined by a narrow white (aplogranite) band and it may be noted that close examination of hand specimens from the boundary indicates that there is apparently no genetic relation between this material and the more acidic bands of the gneiss which appear to belong to an earlier period of granitisation. Both the older gneiss and the younger massive granite are intruded by aplite-pegmatite veins which, as will be seen from the petrological section of this paper, appear to represent an end phase of the younger granite magma. In addition there are, in the older gneiss, patches of darker rock which are remnants of a still earlier basic igneous rock which has been granitised and migmatised to form the older hybrid gneisses.

Figure 2 in Plate 1 is a view of a boulder showing the sharply defined border of the younger granite against the older gneiss—in this boulder the younger granite can be distinctly seen to transgress the more acidic bands of the gneiss. The banded character of the gneiss is evident, the darker coloured bands being thoroughly granitised pre-existing basic rock, the acid bands being more granitic and imparting a migmatitic structure to the rock.

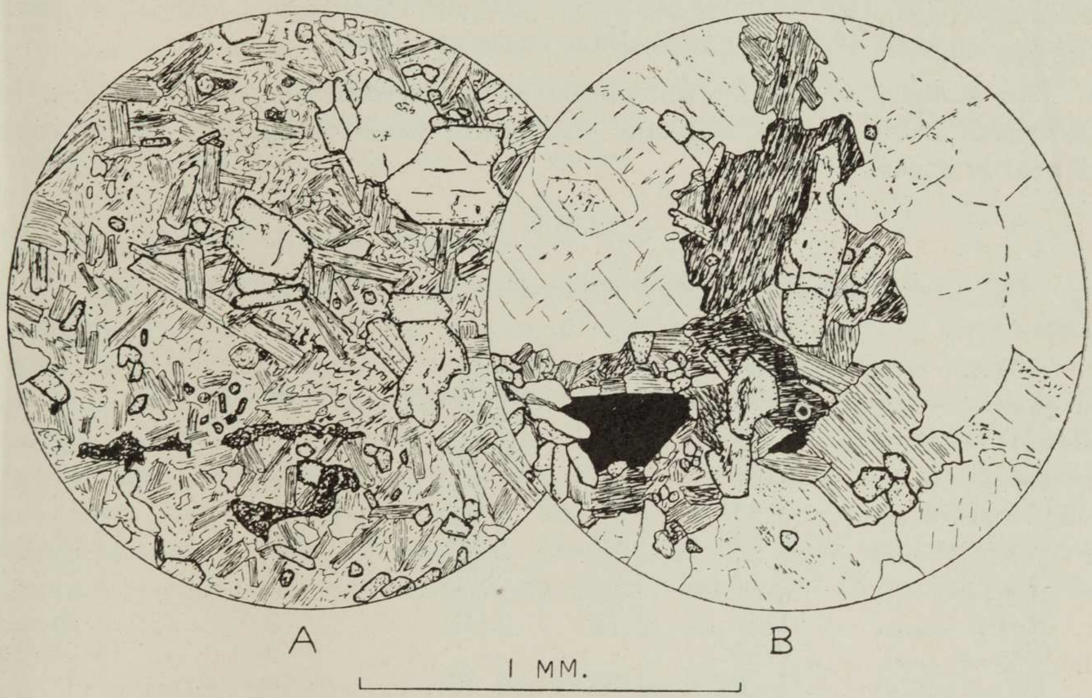
From a study of the rocks in this quarry the age relations appear to be as follows:—

The oldest material is represented by the basic clots and patches in the gneiss, then follows the hybrid gneiss, then the younger granite, and, latest of all, the aplite-pegmatite dykes (it must be remembered that all of the above are intruded by the still later basic dykes which, however, are not being considered in this communication).

PETROLOGY.

(a) The Basic Xenoliths.

These are the fragments of dark greenish rock which are distributed irregularly through the hybrid gneisses. Amongst these rocks there is some variation of character but the most abundant type is an epidote-biotite rock of which specimen 20640* is typical. It is a phaneric, fine, even-grained, almost black rock with no trace of any directed structure and, except for the presence of occasional larger grains of pyrite and very rare grains of plagioclase, appears to be of uniform character throughout. The micro-structure is decussate (text figure 1a), the rock consisting essentially of biotite and epidote with sporadic development of porphyroblastic plagioclase.



Text Figure 1.

A. Basic xenolith (epidote-biotite rock) showing decussate arrangement of biotite, tablets of epidote, irregular areas of granular sphene (enclosing magnetite) and small xenoblastic grains of quartz and albite. The groundmass is of chloritic material.

B. Younger granite showing the aggregate structure of the mafic constituents. The minerals of these basic clots are biotite, magnetite and epidote. The felsic minerals are microperthitic microcline at upper left, quartz at upper right and plagioclase at lower right corners of the field.

Accessories include quartz, rare apatite prisms and magnetite surrounded by granular sphene rims. The biotite is a greenish brown, practically uniaxial variety with X pale yellow brown, Y = Z greenish brown and β = 1.640. The basal faces are well developed but the terminations are ragged and the flakes (which are variable in size up to 0.75 mm. diameter) are arranged haphazardly. The interstices between the biotite flakes are filled with a pale greenish, practically isotropic chlorite towards which the biotite is idioblastic. The epidote is a pale yellowish-green pistachite in well shaped tablets up to

* Numbers refer to the catalogue of the collection of the Geology Dept., University of Western Australia.

0.75 mm. long, uniformly distributed throughout, although in some places the prisms may be clustered together—the epidote is idioblastic towards all other minerals in the rock.

Porphyroblasts of albite up to 1.5 mm. diameter are distributed sporadically—they are always xenoblastic and enclose small grains of epidote and bright green chloritised biotite and appear to be of late introduction, probably representing the first stages of the granitisation of the rock.

The accessories are apatite and magnetite; the latter is associated with granular sphene which indicates its origin from original ilmenite.

The rock is very similar to the basic xenoliths noted by Thomson (1941, p. 271) in the gneisses at Cardup and to the basic xenoliths in the gneiss at Armadale (Prider, 1941, p. 34), although the latter contain considerable hornblende. It may be noted, however, that hornblende was present in small amount in some of the Canning Dam basic xenoliths.

An analysis of the biotite-epidote rock described above is set down in Column 2, Table 1, along with the analyses of basic xenoliths in the gneisses of nearby areas.

TABLE I.

Analyses of Basic Xenoliths in the Darling Range Gneisses.

	1.	2.	3.
SiO_2	40·09	41·42	44·95
Al_2O_3	14·01	16·55	17·70
Fe_2O_3	6·05	2·21	3·12
FeO	14·42	14·28	11·32
MgO	4·34	8·41	6·08
CaO	9·89	3·95	3·08
Na_2O	0·46	2·36	3·03
K_2O	3·78	5·68	6·38
H_2O-	0·07	0·26	0·12
H_2O+	1·97	2·14	1·41
CO_2	0·08	...	...
TiO_2	2·76	1·92	1·36
BaO	*Nil*	Tr.	...
P_2O_5	1·24	0·53	0·95
MnO	0·38	0·15	0·14
FeS_2	0·77	0·64	...
Fe_7S_8	0·02	...	...
V_2O_3	0·03	...	...
	100·36	100·50	99·64
Sp. Gr.	3·23	3·00	2·94

Norm of (2).

or	18·90
an	16·12
le	11·77
ne	10·79
ol	31·32
C	0·51
il	3·65
mg	3·25
ap	1·34
py	0·64

Classification—

III. 7 . 2 . 3

1. Hornblende-epidote-biotite hornfels, xenolithic in hybrid gneiss, Armadale, Western Australia (Prider, 1941, p. 36).
2. Epidote-biotite rock (20640), xenolith in hybrid gneiss, Canning Dam Quarry, Canning Dam, Western Australia. *Anal.*—R. T. Prider.
3. Basic xenolith in gneiss, Cardup, Western Australia (Thomson, 1941, p. 271).

All of these analyses have the same unusual features of a low SiO_2 content associated with high potash and alumina. The Canning Dam and Cardup rocks (analyses 2 and 3) are of very similar chemical composition and differ from the Armadale rock (analysis 1) mainly in the MgO/CaO ratio. The unusual character of these basic xenoliths in the Darling Range gneisses may be shown by an endeavour to place them in the Quantitative Classification—the classification of the Canning Dam specimen (analysis 2) is III.7.2.3 and the only other members of this classification are rare leucite basalts and tephrites. The general chemical features of these rocks (except for their high FeO/MgO ratio) are similar to the basic hybrid rocks of Ach'uaine, Sutherlandshire, Scotland, which are considered by Read *et al* (1926, p. 154) to be hybrids between ultrabasic rocks and felspathic magma.

The three analyses quoted in Table 1 show serial characteristics for all the main oxides except MgO—with increasing SiO_2 there is a gradual increase in K_2O, Al_2O_3 and Na_2O and a corresponding decrease in Fe_2O_3 + FeO, CaO and TiO_2. These constant variations are reflected in the specific gravities of the various rocks. The Armadale rock, in view of certain relict structures, was considered (Prider, 1941, p. 35-37) to have been originally a basic igneous rock which was altered by addition of potash from potash- and alumina-rich solutions from an intrusive granite (the hybrid gneiss). No such relict structures are present in the basic xenoliths at Canning Dam and Cardup which appear to be more completely metasomatised rocks of similar origin to the Armadale rock—this is supported by the higher potash, alumina and silica content of these rocks.

(b) The Hybrid Granite Gneisses.

These rocks are even-medium-grained with, in places, a well developed gneissic structure due to alternations of light and dark coloured bands which may be as much as several inches wide and may be somewhat lenticular in shape. Both the dark and light coloured bands are sharply truncated by the more coarsely crystalline younger granite. In other places the hybrid granite gneiss may be represented by a granitic gneiss with a very faint gneissic structure and occasional lenticular basic clots—this rock is distinguishable macroscopically from the younger granite by the faint gneissic structure due to a subparallel alignment of the biotite flakes and by its slightly finer grain.

The hybrid gneisses may be described as follows:—

(i) *The basic bands.*—These are fine- to medium-grained, dark in colour, containing abundant biotite in flakes of the order of 1 mm. diameter and occasional small irregular felsic areas. The constituents are biotite, hornblende, plagioclase, quartz, epidote, magnetite, sphene and apatite. The proportions of the main constituents vary from place to place, sometimes biotite (with associated epidote as in the basic xenoliths described above) is the sole ferromagnesian, sometimes it is accompanied by an approximately equal amount of a brownish green hornblende. In all instances the structure is granoblastic even-grained. The biotite, in the biotite-rich layers, occurs in clotted aggregates associated with epidote and rare magnetite grains recalling the structure of the basic xenoliths; some of these clotted aggregates are included in anhedral plagioclase grains. Plagioclase, however, more usually occurs in allotriomorphic granular mosaics with quartz and these mosaics occupy the spaces between the biotitic aggregates or between larger isolated biotite flakes. The plagioclase is clear to slightly dusty with kaolinic alteration products and appears to be constant in character (approximately $Ab_{85}An_{15}$) with very slight normal gradational zoning (the extinction of centre and periphery differing only by 2° or 3°). Quartz, the last mineral to crystallise, is always anhedral, varies in size up to 3 mm. diameter and all shows undulose extinction.

The structure of the hornblende bearing bands is even grained (average grain size 0.3 mm.) granoblastic with no tendency to a preferred orientation for any of the constituents. The minerals present are hornblende (20%), biotite (25%), oligoclase (40%), epidote (3%), magnetite (7%), sphene (3%), with minor amounts of quartz, apatite and zircon. The biotite is the brownish green type which occurs in the basic xenoliths and is idioblastic towards the hornblende which is a brownish green variety with X yellow green, Y brownish green, Z green (slightly bluish) and $X < Y \lessapprox Z$. The plagioclase is always allotriomorphic, unaltered, and shows lamellar twinning in about half of the grains present. Quartz is always allotriomorphic and interstitial and is present only in small amount. Sphene is comparatively abundant, usually rimming magnetite euhedra; in some instances it is present in grains to 0.5 mm. diameter enclosing a number of separate magnetite grains: this magnetite-sphene association is clearly derived from original ilmenite.

(ii) *The acid bands.*—These bands appear to be normal granitic rocks with a slight gneissic structure. They are even-grained and under the microscope the subparallel alignment of the biotite flakes is visible and also a slight tendency to the elongation of quartz anhedra parallel to the gneissic banding. The constituents are oligoclase (50%), quartz (45%), biotite (5%), epidote ($<1\%$) and very rare apatite. All constituents (except the rare epidote and apatite) are allotriomorphic. The biotite is the usual brownish green variety similar to that of the basic xenoliths and occurs as isolated flakes or in clotted aggregates (which may contain an occasional epidote grain and which are elongated parallel to the gneissic structure). The plagioclase is slightly turbid by alteration and is generally rather free from twinning. No zoning is visible and it is an oligoclase (approximately $Ab_{85}An_{15}$). The quartz occurs in allotriomorphic grains which tend to be slightly elongated parallel to the gneissic structure. It all shows undulose extinction due to strain. There is a complete absence of microperthitic microcline, which is a characteristic constituent of the younger granite, and this affords one of the best means for distinguishing the two rock types.

The hybrid gneisses appear then to represent a series of basic and ultrabasic igneous rocks which have been metasomatised by alkalic solutions or vapours derived from a granitic magma (which has resulted mainly in the development of biotite from pre-existing ferromagnesian minerals) and migmatised by injection of granitic magma along foliation planes to give the more acid bands—this granitic magma itself being hybridised by the assimilation of some of the basic material. These two processes were effected simultaneously at an earlier period than the intrusion of the younger granite (as deduced from field relations and the different mineralogical composition of the hybrid granitic gneisses and the younger granite which is described below).

(c) The Younger Granite.

The younger granite is a massive, even, medium-grained rock which is more leucocratic than the hybrid gneisses and lacks the banded structure. It carries small pegmatitic segregations and may be traversed by aplite-pegmatite veins which also traverse the xenoliths of hybrid gneiss enclosed by the younger granite—these pegmatites (which are described in a later section) appear to be end phase products of the younger granite magma.

The typical younger granite (e.g. spec. 20641) is massive, leucocratic, even-medium-grained (average grain size 1-2 mm.) with local pegmatitic segregations. A noticeable feature in hand specimen is that the mafic minerals occur in small aggregates (to 2 mm. diameter) distributed uniformly throughout the rock rather than as isolated biotite flakes. Under the microscope the texture is granitic, all the constituents being allotriomorphic. The minerals present are microcline, oligoclase, quartz and biotite, with accessory magnetite and epidote.

Biotite occurs in clotted aggregates associated with magnetite and epidote (text figure 1B). It is the greenish brown variety, similar in all respects to that of the basic xenoliths described above. The epidote is similar to that of the basic xenoliths both in regard to type and relations with the biotite. Magnetite, though comparatively rare, was found to form the greater part of several of these aggregates which were approximately 2 mm. diameter. These clotted aggregates resemble the basic xenoliths in the hybrid gneiss so closely that they must be regarded as micro-xenolithic bodies in the younger granite and indicate that this magma has also been hybridised to some extent.

Of the felspars the plagioclase, although generally anhedral, may at times show subhedral form. It is invariably dusted with small granules of epidote and flakes of muscovite—these secondary products at times completely replace the plagioclase and are often recrystallised into epidote-muscovite aggregates. Lamellar twinning is occasionally present and the mineral, which appears to be constant in character, is an oligoclase close to $Ab_{80}An_{20}$. The oligoclase carries occasional rounded quartz inclusions of the order of 0.15 mm. diameter.

The microcline, which is generally microperthitic, is always anhedral and by contrast with the oligoclase is water-clear with no evidence of alteration—it shows a tendency to wrap around and at times completely enclose the more turbid oligoclase and is undoubtedly of later crystallisation. The pegmatitic segregations which occur sporadically in the younger granite consist in the main of this microperthitic microcline in anhedral Carlsbad twins up to one cm. in length with quartz and minor amounts of oligoclase (again subhedral and exhibiting the characteristic alteration as in the finer even grained granite).

Quartz the only other mineral of importance in this rock is in anhedral grains to 1 mm. diameter, and all shows strain shadows under crossed nicols. The presence of rounded quartz inclusions in the oligoclase has been noted above.

The presence of micro-xenoliths of the epidote-biotite rock and of rounded quartz inclusions in the oligoclase indicates that the granite magma from which these rocks were derived was of syntectic origin, being either (a) developed by the fusion of the pre-existing granite-gneisses or (b) hybridised by partial assimilation of the pre-existing hybrid gneisses—the recrystallised epidote-muscovite aggregates after plagioclase probably represent an older plagioclase derived from the same source. The very uniform distribution of these older constituents throughout the rock indicates the thoroughness with which the admixture of pre-existing rock and granite magma has been effected and points to this hybridisation being effected at considerable depth followed by the intrusion of the hybridised magma into the earlier granitic gneisses.

A chemical analysis of the younger granite is given in Table II.

TABLE II.

Analysis of Younger Granite (20641) *from Canning Dam Quarry.*

SiO_2	74·80		
Al_2O_3	13·93	Norm—	
Fe_2O_3	0·78	Q	34·86
FeO	0·97		
MgO	0·22	Or	19·46
CaO	1·92	Ab	33·01
Na_2O	3·89	An	9·17
K_2O	3·30		
H_2O+	0·14	C	0·51
H_2O-	0·24		
TiO_2	0·14	hy	1·42
BaO	*Nil*		
P_2O_5	0·05	mg	1·16
MnO	0·02	il	0·30
	100·40	ap	0·17
Sp. Gr.	2·66	Classification—1 . 4 . 2 . 4	

Anal.—R. T. Prider.

(d) The Pegmatites and Related Rocks.

As has been noted above there are two different types of pegmatite masses:—(i) Segregations in the younger granite and (ii) veins up to several feet wide intrusive into the younger granite and older hybrid gneisses. In addition there are narrow mineralised zones in the younger granite which appear to be genetically related to the pegmatite.

(i) The segregations vary in size up to several inches across and consist largely of microperthitic microcline in Carlsbad twins up to 1 cm. long with quartz and minor amounts of oligoclase. There is a noticeable concentration of ferromagnesian minerals into a narrow zone several mm. wide around the edges of these segregations—in thin section this dark coloured material is seen to consist of brownish biotite associated with prismatic epidote, anhedral sphene with magnetite inclusions and euhedral magnetite (often with biotite flakes coating its surfaces). The structure of these patches is similar to that of the basic xenoliths, but a noticeable feature is the somewhat stronger absorption of the biotite in the pegmatite—in view of the structure and mineralogical composition these basic patches in the pegmatite segregations appear to be of the same origin as those in the granite.

(ii) The pegmatite veins are of two types—perthite bearing pegmatites and magnetite-pegmatites:—

The ***perthite bearing pegmatite*** which is the more abundant of these two types, is similar in all respects, except for a very much coarser grain, to the pegmatitic segregations in the younger granite and is undoubtedly related to the younger granite magma. It has a coarse pegmatitic texture, the constituents (up to 10 cm. diameter) being pale brownish grey perthitic microcline, milky white oligoclase, bluish white quartz, and black platy forms of the order of 5 cm. across, which at a distance appear to be large biotite flakes. Microscopic examination shows that these plates are fragments of an epidote-muscovite-biotite schist—the laminae of such "plates" consist of bands 0.3 mm. wide made up of a decussate aggregate of greenish brown biotite plates of the order of 0.08 mm. diameter peppered with minute epidote granules, alternating with narrower biotite-muscovite bands with a similar decussate structure. These laminae have, in places, been prised apart by later crystallising microcline and oligoclase, clearly indicating the earlier origin of these fragments. The nature of the biotite and the decussate structure suggest that these platy fragments are remnants of a schistose type of basic xenolith (similar to those described above) which has been engulfed by the pegmatite.

The *magnetite-pegmatite* was noted in one place only in a large boulder broken out during quarrying operations. In this boulder the pegmatite traverses the banding of the hybrid gneiss and a noticeable feature is that the magnetite is confined to a zone approximately three inches wide at the edge of the dyke—unfortunately only one edge of the dyke is exposed so that no information can be gained as to whether or no this segregation is due to a gravitative separation of early formed magnetite. The magnetite, which forms at least 50% of the bulk of the edge zone of the dyke, is in closely spaced crystals up to 3 cm. diameter in a pegmatitic quartz-oligoclase groundmass. It has a well developed octahedral cleavage and is generally rimmed with a decussate aggregate of deep brown biotite which may also be developed along irregular cracks. At times these biotitic aggregates may completely replace the magnetite except for small irregular shaped relicts. Polished surfaces of the rock show that the biotitic rim is developed when the magnetite is in contact with oligoclase, but not when the contact is with quartz, indicating the origin of the biotite as a reaction product between the magnetite and oligoclase. The magnetite is also replaced in part by pyrite.

The central part of the magnetite-bearing pegmatite dyke is practically free from magnetite and is irregular in grain consisting mainly of medium grained granitic material with pegmatitic patches (in which felspars may be up to 5 cm. diameter) and streaks of aplite several inches wide, running parallel to the walls of the dyke. The granite portion of this rock is made up of an allotriomorphic granular mosaic of oligoclase and quartz with small mafic areas composed of biotite-epidote aggregates. The oligoclase is peppered with small muscovite flakes and epidote granules. Microcline is absent. The pegmatitic areas consist essentially of quartz and oligoclase and again microcline is absent. The aplite streaks on the other hand are rich in microperthitic microcline, consisting of an even grained granitic aggregate of microcline, oligoclase and quartz, and containing occasional small crystals of magnetite associated with epidote. Considering the dyke as a whole it appears that magnetite was the first mineral to crystallise, followed by the oligoclase granite (at which time the early formed magnetite suffered peripheral alteration to biotite) and then by the last phase rich in microcline (the aplites). In view of the presence of microperthitic microcline in the aplitic phase there can be little doubt that the magnetite pegmatites are genetically related to the younger granite magma, although they probably represent an earlier pegmatitic phase than the perthite-bearing pegmatites described above.

The magnetite pegmatites are very similar mineralogically, structurally, and in their associated rocks to the magnetite-pegmatites of Vermilion, Minnesota, U.S.A. (described by Grout, 1923) and those of Clinton Co., New York, U.S.A. (described by Miller, 1919 and 1921). Miller considers that the pegmatites of Clinton County, which are associated with granite-syenite intrusions into an older meta gabbro series, derived much of their iron from the older meta-gabbros. Grout on the other hand considers that, in the case of the Vermilion pegmatites, the iron was first concentrated from a granite low in iron, into the pegmatites by the segregation of those pegmatites and then locally concentrated in some of the late pegmatites, rather than that it was derived by assimilation of the country rock. The magnetite pegmatites of Canning Dam are related to a granitic magma which has undoubtedly been considerably altered by assimilation of pre-existing basic rocks very rich in iron (14.28% FeO, 2.21% Fe_2O_3—see analysis 2 in Table 1) and although the magnetite is a primary mineral in the pegmatite it seems most likely that the original source of the iron was the older basic rocks that have left their imprint on all of the later intrusives (with the exception of the epidiorites which represent a still later phase of igneous activity than has been considered in this paper).

SULPHIDE MINERALISATION OF THE GRANITES.

Two sulphide minerals have been noted in the Canning Dam granitic rocks, molybdenite and pyrite. The former was found in very small amount associated with small quartz segregations in the older hybrid gneiss. The latter occurs in a rock which can only be described as a pyrite granite, which occurs in veins several feet wide in the younger granite, and which is variable in texture from even medium-grained to coarse pegmatite. It is similar in all respects to the younger granite, consisting of microperthitic microcline, oligoclase and quartz, with the addition of up to 20% of pyrite which has the appearance of being a primary mineral of rather late crystallisation. The pyrite is coarse grained, comparable in size to the associated quartz and felspar grains and is anhedral, often being moulded around the felspar. Pegmatitic segregations in this granite (similar to those described under (i) above) also carry pyrite in grains 3 mm. diameter completely enclosed in large microcline crystals and as thin films along cleavage planes in the same crystal. In spite of the primary appearance of the pyrite it is difficult to think of it as being other than a replacement mineral and this suggestion of its origin is supported by the facts that the minerals of the associated granitic material all show signs of strain (undulose extinction of quartz grains and bending of the twin lamellae in the plagioclase) and that pyrite does occur as thin films along the cleavages of the last mineral to crystallise, viz., the microcline, in the pegmatitic segregations.

SUMMARY AND CONCLUSIONS.

The complex nature of the Darling Range "granite" is only fully realised when freshly broken exposures in quarries are examined. At Canning Dam this granite complex consists (from older to younger) of:—

(a) Older basic rocks now represented by a variety of hornblende-biotite-epidote hornfelses which are considered to be derived from pre-existing basic igneous rocks. These occur in xenolithic patches in (b).

(b) Hybrid granite gneisses which have been formed by the thorough granitisation (both by metasomatism and migmatisation) of the older basic rocks.

(c) Younger microcline granite which has engulfed both (a) and (b) which now remain only in xenolithic form. It is considered that this granite intrusion belongs to a distinctly later period than the granite which gave rise to the hybrid granite gneisses. The younger granite magma was of syntectic origin being either highly hybridised by assimilation of pre-existing rocks or developed by fusion of the earlier granitic gneisses.

(d) End phases of the younger granite magma which have extensively ·ined all of the abovementioned rocks. These end phases include aplites and ·gmatites of various types, of which the magnetite pegmatites are con-·dered to have derived their iron content from the oldest basic rocks.

(e) Sulphide replacements of narrow zones in the younger granite. ·etrographical details regarding all the above members of the complex are ·iven in the paper. All these rocks are traversed by still younger epidiorite ·ykes which have not been considered in this paper as they have produced ·o visible effects on the granitic rocks.

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EXPLANATION OF PLATE I.

Figure 1: View of wall at the south-east corner of the quarry showing a large xenolith of the hybrid granitic gneiss in the younger granite which occupies most of the left hand side of the photograph. Smaller xenoliths of the older gneiss in the younger granite are present in lower left corner. Note the contorted structure of the gneiss and the dark coloured remnants of the older epidote-biotite rock (the light coloured patches seen in the gneiss are defects in the photograph). Both the older gneiss and younger granite are traversed by a network of aplite-pegmatite dykes. The dimensions of the area shown in the photograph are 15 feet x 10 feet. *Photo by R. G. Royce.*

Figure 2: Photograph of boulder showing younger granite (upper left) transgressing the foliation of the gneiss. Shows also the migmatitic structure of the gneiss. Dark area in lower left is shadow below the boulder. Clinometer rule (arms 6 inches long) gives the scale. *Photo by R. G. Royce.*

Fig. 1.

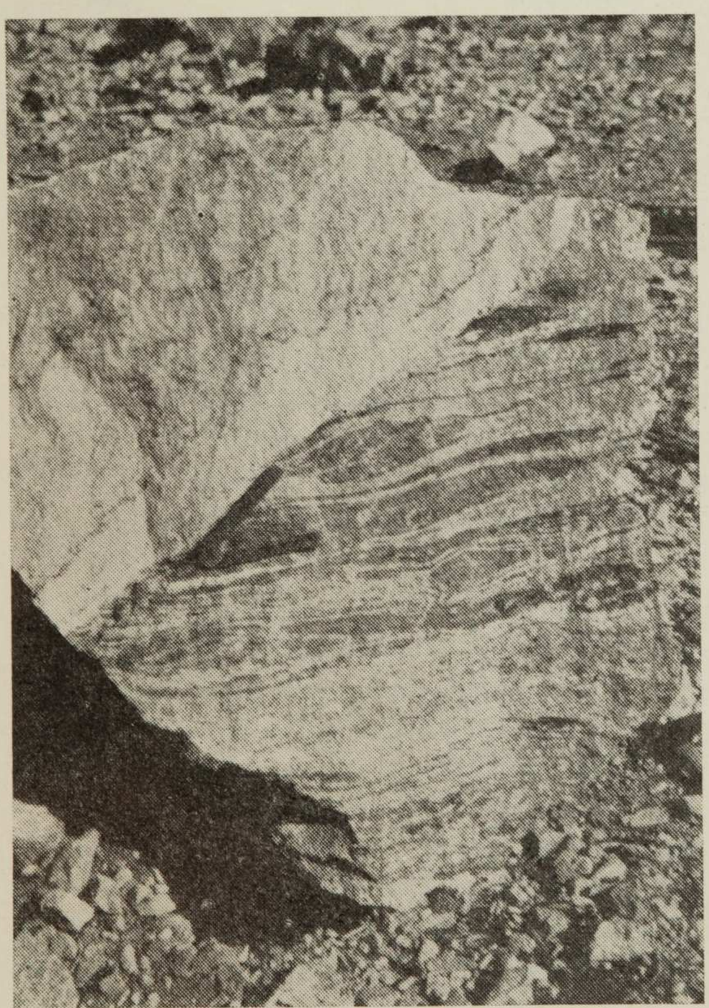

Fig. 2.

PLATE I.